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54 Treatment of clays with cationic polymers to prepare high bulking pigments.

57 A highly bulked kaolin pigment is prepared by mixing a small but effective amount of a water-soluble cationic polyelectrolyte flocculant with a kaolin clay pigment in the presence of water to prepare a bulked clay pigment product. Upon dewatering, the resultant polyelectrolyte treated clay product can be dispersed to form high solids clay-water slurries useful in making aqueous coating colors suitable for manufacturing coating lightweight publication papers or the pigment can be used as a filler for paper webs.

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TREATMENT OF CLAYS WITH CATIONIC POLYMERS
TO PREPARE HIGH BULKING PIGMENTS

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This invention relates to the production of kaolin clay pigments and, more particularly, to novel high bulking kaolin clay pigments for printing papers.

15 Finely divided refined kaolin clay is widely used as a pigment to provide a glossy, white opaque surface finish on printing paper. The clay is applied as an aqueous "coating color" which comprises a clay pigment, a dispersing agent for the clay, a suitable adhesive such as
20 a polymer latex, starch, or mixtures thereof and other minor additives. Present-day coatings are applied at high machine speeds which necessitate the use of high solids coating colors. The formulation of coating colors at high solids requires the initial provision of fluid high solids
25 clay-water suspensions or "slips". These suspensions are subsequently mixed with adhesive dispersions or suspensions to prepare the coating colors. High solids clay-water suspensions of hydrous (uncalcined) clays generally contain in excess of 65% clay solids (65 parts by weight dry clay
30 to 35 parts by weight water). Typically, solids are about 70%. A dispersing (deflocculating) agent, conventionally a sodium condensed phosphate salt, or sodium polyacrylate, is present in the high solids suspensions in order to impart fluidity, since the systems do not flow in the absence of
35 the dispersing agent.

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1 Kaolin clay pigments must meet certain
requirements with regard to rheological properties and to
the properties of the coated sheet material. The viscosity
of the high solids suspension of the clay coating pigment
5 must be sufficiently low to permit mixing and pumping.
After the adhesive is incorporated, the resulting coating
color must also have suitable viscosity for handling and
application to the paper sheet. In addition, it is highly
desirable to obtain a coated calendered sheet which has
10 good opacity, gloss, brightness and printability.

It is the conventional practice in the art to
improve the opacifying or hiding power of coating colors by
blending the clay pigments with more costly pigments having
greater opacifying power, such as TiO_2 . The industry has
15 long sought a kaolin clay pigment which imparts improved
opacifying power to coated paper without sacrificing gloss
and printability and which can preferably be used in the
absence of other more expensive pigments.

High bulking clay pigments offer the opportunity
20 of maintaining or improving the opacity, gloss and
printability of coated paper incorporated at lower coating
weights, thereby reducing the pigment cost for coating
colors. Bulking pigments are those which provide coatings
having high opacification at a low coat weight. Generally,
25 bulking is achieved by introducing voids in a pigment
structure which contribute to increase light scatter.
Controlled calcination of kaolin clays results in one type
of bulking clay pigment. U. S. Patent Nos. 4,075,030,

4,076,548 and 4,078,941 teach increasing the
30 opacifying power of hydrous kaolin clays by "selectively
flocculating" ultrafine clay particles with a low molecular
weight polyamine flocculating agent (e.g. ethylene diamine
or hexamethylene diamine) or with long carbon chain amines
or certain quaternary ammonium salts (e.g.,
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1 "ditallowdimethyl" ammonium chloride) in the presence of a
mineral acid flocculating agent, e.g., sulfuric acid, and
optionally with the added presence of citric acid or mica
or both. The selective flocculating treatment allegedly
5 incorporates voids in the clay to form a low density, high
bulking pigment which when used as a coating color pigment
improves the opacity of paper coated therewith. These
patents do not disclose the use of polymers nor do they
contain information regarding the ability to disperse the
10 bulked clay to prepare clay-slurries having acceptable
rheological characteristics for commercial use.

We are aware of the fact that efforts to exploit
bulking pigments to the paper industry have been thwarted
among other things by the poor rheology of the pigments.
15 Generally, paper makers seek to use clay coating pigments
capable of forming high solids clay-water slurries which
have a low shear viscosity below 1000 cp, preferably below
500 cp when measured by the Brookfield viscometer at 20
rpm. High shear viscosity for these slurries should be
20 such that they are no more viscous than a slurry having a
Hercules endpoint viscosity of 500 rpm, preferably 800 rpm,
using the "A" bob at 16×10^5 dyne-cm. Those skilled in
the art are aware that when using the Hercules viscometer
and measuring endpoints of 1100 rpm or higher, endpoint
25 viscosities are reported in units of dyne-cm at 1100 rpm;
apparent viscosity decreases as the value for dyne-cm
increases. It is conventional to use the abbreviated term
"dyne". Thus, a "2 dyne" clay slurry is less viscous than
a "9 dyne" clay slurry. As used hereinafter the
30 expressions 500 rpm or higher, or 800 rpm or higher, are
intended to include lower viscosities such that endpoint
measurements are at 1100 rpm and the values are reported as
dynes.

For reasons of economy, the manufacture of
35 refined kaolin pigments usually necessitates sizing and

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1 purifying crude clay while the clay is in the form of a
fluid deflocculated aqueous slurry, bleaching the clay
while in a flocculated state, filtering the flocculated
clay to remove liquid water and then dispersing the
5 flocculated clay to form a high solids slurry that is sold
as such or is dried, usually in a spray dryer, to provide a
dry refined pigment capable of being mixed with water to
form a dispersed fluid suspension. The latter form of clay
is frequently referred to as a "predispersed" grade of clay
10 even though the clay is dry and is not present in dispersed
state until it is mixed with water. Another problem
encountered in the manufacture of bulking pigments from
clay is to produce a bulked structure that is sufficiently
durable to survive during various stages of production and
15 end-use but is also capable of being dispersed to form high
solids clay-water slurries having acceptable rheology.
When the general wet processing scheme described above is
employed to make bulked structures by adding a bulking
agent before filtration, the bulked structure must still be
20 present in the filter cake containing the bulked
assemblages when the filter cake is "made down" into a
fluid slurry. The expressions "make down" and "made down"
are conventional in the industry and refer to the
preparation of dispersed pigment-water slurries. In some
25 cases, it may be necessary to apply mechanical work to the
filter cake to reduce the low shear viscosity to usable
values. The bulked structure must be sufficiently
tenacious to survive the mechanical forces during such
treatment. Bulking pigments must also be sufficiently
30 stable under the influence of shear to maintain the bulked
structure under the high shear rates encountered in pumping
high solids clay water slurries. Moreover, a bulked
structure must be capable of being retained when the
deflocculated clay water slurry is formed into a coating
35 color using standard makedown equipment. Also, the bulked
structure must survive during the coating application and

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1 subsequent calendering. The fragility of the bulked
structures obtained by chemical treatments of hydrous clays
has limited their commercial use. Commercial bulking clays
heretofore used by the paper industry are prepared by
5 calcining fine particle size hydrous clays. In such case,
calcination "sets" the bulked structure such that it is
sufficiently durable to survive during manufacturing
handling and use. Generally, a criterion for durability of
a bulked structure is the retention of improved
10 opacification (light scattering).

The present invention makes use of water-soluble
cationic polyelectrolytes to produce bulked hydrous clay
pigments having a combination of desirable
properties. These cationic polyelectrolytes are high
15 charge density materials and have the ability to flocculate
clay-water slurries. Cationic polyelectrolyte flocculants
have been used in the past to clarify various suspensions
such as river waters containing suspended fine solids,
municipal waste and sewage sludge. The efficiency of such
20 flocculants is frequently evaluated by measuring the
ability of the flocculant to clarify clay suspensions. It
is also known that various polymers including certain
cationic polyelectrolytes will increase the rate at which
suspensions of clay filter. However, the use of polymeric
25 filter aids to increase filtration may adversely affect the
rheology of kaolin clay intended for use as high
performance pigments in the paper industry. Furthermore,
filter cake solids are usually decreased when polymers are
used as filter aids. As a result drying costs are
30 increased. This may reduce the economic benefit of
increased filtration rates. To the best of our knowledge,
the quality segment of the clay industry devoted to
producing high performance pigments and fillers does not
utilize polymeric filter aids to produce clay pigments.

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The present invention provides new relatively inexpensive kaolin pigments with a stable bulked structure but also capable of being mixed with water to form clay-water slurries and coating colors having useable low and high shear viscosity. The new bulked pigments when applied to paper at low coat weights result in coated printing paper possessing superior printability, especially by rotogravure and offset methods, superior opacifying power, adequate whiteness and adequate gloss characteristics.

These kaolin pigments can be easily prepared and can improve the printability (by both offset and gravure methods) of pigmented coatings without substantially impairing other desirable properties of the clay.

In accordance with the present invention bulked kaolin pigments are prepared by mixing finely divided kaolin clay in the presence of water with a small but effective amount of water-soluble cationic polyelectrolyte flocculant, preferably a high molecular weight diallyl ammonium polymer salt wherein the ammonium group is either partially substituted with an alkyl group having 1 to 18 carbon atoms or totally substituted with alkyl groups having 1 to 18 carbon atoms. Preferably the polyelectrolyte is added to aqueous suspension of the clay before the suspension is filtered and washed. Preferably, the resulting filter cake is washed with hot water.

A feature of the invention is that the amount of cationic polyelectrolyte used must be sufficient to thicken and flocculate the aqueous slurry of clay to which it is added but the amount of polyelectrolyte, as well as the amount of dispersant used, must also be carefully

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1 controlled to result in a bulked pigment that is capable of
being deflocculated (dispersed) to form clay-water
suspension of 60% solids or higher, which have acceptable
high and low shear viscosity and also have greater
5 opacifying power than the kaolin clay used in making the
pigment.

In practice of the invention, processing steps
must be carefully controlled and the particle size of the
feed clay as well as quantity of reagents, both
10 polyelectrolyte and dispersant, are judiciously selected.
Thus, the pigments of the invention will not be produced
simply by using any quantity of polyelectrolyte that will
flocculate the clay suspension and increase its filtration
rate. If the amount of polyelectrolyte added is selected
15 on the basis of maximizing filtration rate, opacifying
properties may also be improved. However, the pigment will
be useless for all but perhaps a limited number of
specialized markets because the pigment cannot be mixed
with water to form a slurry having a sufficiently high
20 solids level to be used in conventional paper making mills
or if it can, the rheology of the clay-water slurry will be
unsatisfactory. Furthermore, clay pigments of the
invention should be "madedown" into deflocculated
clay-water slurries at solids level of 60% or above but
25 below the conventional 70% level in order to assure that
optical properties are not impaired.

The accompanying figure is a photomicrograph of a
pigment of the invention. The pigment was supplied as a
slurry which was dried in a critical point dryer. After
30 drying, a micrograph of a portion at 30,300 X magnification
was obtained by the SEM procedure. The bar in the figure
represents 1 micrometer.

It has been determined that the shape of the
35 particle size distribution curve of the kaolin clay used to

- 1 produce pigments of the invention has an effect on the ultimate coating properties of the polyelectrolyte treated kaolin clay mineral. Thus, a clay having the following particle size distribution characteristics has been found
- 5 to provide optimum rheology and coating properties: a median particle size of 0.55 micrometers and a particle size distribution such that about $88 \pm 2\%$ of the particles have an equivalent spherical diameter less than about 2 micrometers and not more than about 25% by weight,
- 10 preferably not more than about 20% by weight, have an equivalent spherical diameter less than 0.3 micrometers. If the particle size is too coarse, gloss and opacity suffer although opacity will be greater than the clay before treatment with polyelectrolyte. If the quantity of
- 15 ultrafine particles, i. e., particles 0.3 micrometers and finer, is too great, the rheology of the pigment may be such that it has limited, if any, use.

In order to achieve the desired particle size distribution of the kaolin that is eventually formed into a

20 bulked structure, it is generally necessary to perform one or more particle size separations on the crude clay. Generally, such processing includes degrading, followed by differential gravitational or centrifugal sedimentation to recover a size fraction of desired particle size, such as

25 for example, a fraction that is 90% by weight finer than 2 micrometers and does not contain an excessive amount of ultrafine particles. The content of ultrafines and median (weight) particle size of such fraction will vary, depending on the particle size distribution of the crude

30 clay. In order to perform these operations successfully, it is essential that the clay be present in the form of discrete particles in water rather than flocs so that the particles can be accurately separated into different size ranges. The clay is therefore preferably treated with a

35 deflocculant (dispersing agent) which will give all the

1 particles a negative electric charge, and cause them to
repel each other when the particles are suspended in water.
The clay dispersant used at this stage is generally
referred to as a "primary" dispersant. Dispersants used to
5 deflocculate suspensions of previously processed clay (such
as dispersants added to filter cakes) are termed
"secondary" dispersants or deflocculants. Suitable
dispersing agents used for primary dispersion in practice
of the present are conventional and include water soluble
10 salts of a condensed phosphate, such as a pyrophosphate,
e.g., tetrasodium pyrophosphate, (TSPP), a water soluble
salt of a polysilicic acid, for example, sodium silicate,
or a water soluble organic polymeric dispersing agent, for
example a polyacrylate or a polymethylmethacrylate salt
15 having a molecular weight in the range of about 500 to
about 10,000. The amount of dispersing agent used will
generally be in the range of from about 0.025 to 0.2% by
weight based on the weight of the dry clay. Generally,
particle size separations are performed using deflocculated
20 aqueous suspensions having a solids content of about 20-40%
by weight. Other solids levels may be used to carry out
such separations. The median particle size of the clay
particles that are treated with the cationic
polyelectrolyte may e.g. range from 0.4 to 0.7 micrometers,
25 equivalent spherical diameter (e.s.d.), preferably 0.5 to
0.6 micrometers, as determined by conventional
sedimentation techniques using the SEDIGRAPH^R particle
size analyzer, supplied by Micromeretics, Inc. From about
80% to 95% by weight of the particles are preferably finer than
30 2 micrometers, e.s.d. The content of fines below 0.3
micrometer e.s.d. is preferably below 35 weight percent, more
preferably below 25 weight percent, and most preferably 20
weight percent or below. It should be understood that the
measurements of the size of clay particles that are 0.3
35 micrometer or finer are of limited reproducibility. Thus,

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1 when a SEDIGRAPH analyzer is employed, the value for weight
percent may be $\pm 5\%$ when tested by another operator or a
different SEDIGRAPH analyzer is employed. Most preferably,
median particle size is 0.6 ± 0.05 micrometers, e.s.d.,
5 with 85 to 90% by weight of the particles finer than 2
micrometers, e.s.d., and less than about 20% by weight or
less finer than 0.30 micrometers, e.s.d. Present
experience indicates that when the clay to which
polyelectrolyte is added contains an excessive amount of
10 ultrafine particles (particles 0.3 micrometers or finer),
the Brookfield viscosity may be higher than and Hercules
viscosity lower than bulked pigments obtained from clays
with a smaller amount of ultrafine particle. One trial
resulted in a failure because of excessively high low shear
15 viscosity of the product when the feed clay contained more
than the desired amount of particles finer than 0.3
micrometers. Blending of clay fractions may be
advantageous or necessary with some crudes to provide a
clay feed having a desirable particle size distribution.

20 The amount of polyelectrolyte employed is
carefully controlled to be sufficient to improve the
opacity of the clay as a result of forming a bulked
(aggregated) structure in which the aggregates are
sufficiently strong to survive mechanical forces exerted
25 during manufacture and end use but is carefully limited so
as to assure that the product can be formed into a
clay-water slurry that has a solids content of 60% or
higher, which slurry has acceptable rheology.

The amount of the cationic polyelectrolyte salt
30 used to treat the kaolin clay may vary with characteristics
of the polyelectrolyte including charge density of the
polyelectrolyte, the particle size distribution of the clay
and solids content of the clay slurry to which the
polyelectrolyte is added. Using the presently preferred
35 dimethyldiallyl ammonium salt polyelectrolyte with clay

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1 having a median size in the range of about 0.5 to 0.6
micrometers, and having less than 20% finer than 0.3
micrometers and adding polyelectrolyte to a previously
deflocculated clay-water suspension having a clay solids
5 content of about 20-40% by weight, useful amounts range
from about 0.03 to about 0.15% by weight of the moisture
free weight of the clay, most preferably about 0.07 to
about 0.1% by weight. When insufficient polyelectrolyte is
used, the effect on opacity and printability in coating
10 applications may be less than desired. On the other hand,
an excessive amount of the polyelectrolyte may impair other
desired properties of the clay, especially rheology.

The polyelectrolyte, which is water soluble, can be
added to the slurry as a dilute aqueous solution, e. g.,
15 1/4-2% concentration on a weight basis, with agitation to
achieve good distribution in the slurry. Ambient
temperature can be used. It may be advantageous to heat
the slurry of clay, solution of polyelectrolyte, or both to
about 150° to 180°F. The cationic polyelectrolyte
20 flocculants that are used have closely spaced charged
centers and therefore are high charge density
materials. Because of this, the reaction with the clay
mineral is extremely rapid and appears to be complete in a
relatively short time. While we do not wish to be limited
25 by any particulars of the reaction mechanisms, we believe
that the clay mineral cations such as H^+ , Na^+ , and
 Ca^{++} are replaced with the positively charged polymeric
portion of the cationic polyelectrolyte at the original
mineral cation location and that this replacement reduces
30 the negative charge on the clay particles which in turn
leads to coalescence by mutual attraction. Charge centers
near the end of the polymer chain react and bridge with
neighboring particles until the accessible clay cation
exchange centers or the polymer charge centers are
35 exhausted. The bridging strengthens the bond between the

1 particles, thereby providing a highly shear resistant,
bulked clay mineral composition. The presence of chloride
ions in the filtrate in the case of dimethyldiallyl
ammonium chloride may be an indication that at least one
5 stage of the reaction between clay particles and quaternary
salt polymer occurs by an ion-exchange mechanism. The
amount of polyelectrolyte added is less than that
calculated to provide a monolayer on the surface of clay
particles.

10 Water soluble cationic polyelectrolyte
flocclulants are well known in the art and many are known to
increase the rate at which clay slurries filter - see, for
example, U. S. 4,174,279. Cationic polyelectrolyte
flocclulants are characterized by a high density of positive
15 charge. (Positive charge density is calculated by dividing
the total number of positive charges per molecule by the
molecular weight.) Generally the high charge density of
polyelectrolyte flocclulants exceeds 1×10^{-3} and such
materials do not contain negative groups such as carboxyl
20 or carbonyl groups. In addition to the alkyldiallyl
quaternary ammonium salts, other quaternary ammonium
cationic flocclulants are obtained by copolymerizing
aliphatic secondary amines with epichlorohydrin. See U. S.
4,174,279. Still other water-soluble cationic
25 polyelectrolyte are poly (quaternary ammonium) polyether
salts that contain quaternary nitrogen in a polymeric
backbone and are chain extended by ether groups. They are
prepared from water-soluble poly (quaternary ammonium
salts) containing pendant hydroxyl groups and
30 bifunctionally reactive chain extending agents; such
polyelectrolytes are prepared by treating N, N, N(1),
N(1) tetraalkyl-hydroxy- alkylenediamine and organic
dihalide such as dihydroalkane or dihaloether with
epoxy haloalkane. Such polyelectrolytes and their use in
35 flocculating clay are disclosed in U. S. 3,663,461. Other

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1 water-soluble cationic polyelectrolyte flocculants are
polyamines. Polyamine flocculants are usually supplied
commercially under trade designations and chemical
structure and molecular weight are not provided by the
5 suppliers.

A dimethyl diallyl quaternary ammonium chloride
polymer commercially available under the trademark
designation Polymer 261 LV from the Calgon Corporation
having a molecular weight estimated to be between
10 50,000-250,000 has been found particularly useful in the
practice of the present invention and has FDA approval
(Code 176-170) for aqueous and fatty food use. Many
reagents heretofore proposed to bulk clay do not have FDA
approval. However, the invention is not limited to Polymer
15 261 LV since other cationic flocculants appear to provide
equivalent, if not superior results.

Limited experimental work with kaolin clay that
produced desired results using 0.08% Calgon 261 LV polymer
(dimethyl diallyl ammonium chloride, said by the supplier
20 to have a molecular weight between 50,000 and 250,000)
indicates that similar results would be expected with
water-soluble cationic flocculants supplied with the
following trademarks when used in the quantities indicated
(100% active weight basis): NALCOLYTE^R 7107 (0.25%),
25 NALCLEAR^R 7122 (1.00%), NALCOLYTE^R 8102, (0.50%),
NALCOLYTE^R 8101 (1.0%), NALCOLYTE^R 8100 (1.0%).
Information from the suppliers indicates that these
polyelectrolytes are:

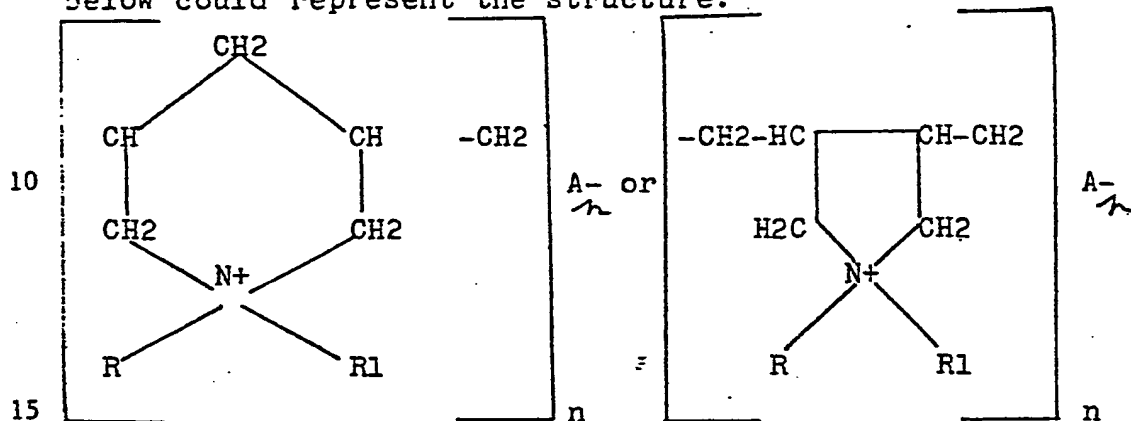
NALCLEAR 7122-water/oil emulsion of
30 aminomethylated polyacrylamide quaternary, low molecular
weight.

NALCOLYTE 8101-aqueous solution of polyquaternary
amine chloride, moderate molecular weight.

NALCOLYTE 7107-aqueous solution of polyamine, low
35 molecular weight.

- 1 NALCOLYTE 8100-aqueous solution of quaternary polyamine,
moderate molecular weight.

The exact structural formula of the preferred
diallyl polymers has not been completely delineated. It is
5 believed that either of the two ring structures set forth
below could represent the structure.



wherein: R and R1 are selected from hydrogen and alkyl
group of 1 to 18 carbon atoms, n indicates repeating units,
and A⁻ is an anion such as Cl⁻. The preferred
compounds are dialkyl diallyl quaternary ammonium salt
20 polymers which contain alkyl groups R and R1 of 1 to 4
carbon atoms, preferably methyl, and n is an integer of 5
to 1000. Such polyelectrolytes are known flocculating
agents. For example, U. S. 3,994,806 and U. S. 4,450,092
disclose the use of dimethyl diallyl ammonium chloride salt
25 polymers in combination with aluminum and iron salts or a
polyacrylamide in coagulating finely divided solids in
turbid waters. It should be understood that incorporation
of other anions in place of chloride ion is possible,
although performance could be affected. Examples of such
30 other anions are acetate, sulfate, nitrate and hydroxide.

Satisfactory results have been realized when the
polyelectrolyte was added to deflocculated clay suspensions
having pH values in the range of 6 to 9. After addition of
polyelectrolyte, the suspension is substantially thickened
35 as a result of flocculation. The resulting thickened

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1 system can then be acidified, typically to a pH below 5,
usually pH 3-4, and bleached using a conventional clay
bleach (hydrosulfite salt such as sodium hydrosulfite) and
then at least partially dewatered to remove free water and
5 place the recovered bulked clay in a form such that it can
be washed to remove ions in the flocculated clay
suspension. Normally dewatering is carried out on a
filter, for example a rotary vacuum filter.

Bleaches are usually reductants which reduce any
10 color forming ferric iron (Fe^{3+}) constituents to a more
water soluble and therefore more easily removeable ferrous
state (Fe^{2+}). Suitable bleaching agents include water
soluble hydrosulfite salts, and borohydride salts which are
advantageously added to the clay mineral slurry in an
15 amount in the range of from 1 to 15 lb., most preferably
about 2 to 6 lbs., of bleaching agent per ton of dry clay.
The slurry of polymer treated clay is acidified before
filtration in order to enhance filtration even if bleaching
is not carried out.

20 The clay suspension may be dewatered by filtering to
a moist filter cake having a solids content of
about 50 to about 60% by weight. The filter cake can then be
washed to remove soluble material and then fluidized by the
addition of a secondary dispersing agent such as
25 tetrasodium pyrophosphate to the filter cake suitably at a
concentration of about 0.01 to about 1.0 percent by weight
based on the dry clay solids and preferably about 0.05 to
about 0.15 percent by weight. Polyacrylate salts are
preferably used to fluidize the filtercake although
30 mixtures thereof with condensed phosphate salt or a
condensed phosphate salt alone may be used. The pH is
usually kept between 6.0 and 7.5.

The presence of the polyelectrolyte significantly
improves the rate of dewatering that can be achieved with
35 conventional filtration equipment (e.g., a rotary vacuum

1 filter) during the processing of the pigment. Thus, the
presence of polyelectrolyte during filtration decreases
filtration costs, and the increased filtration rate
compensates in part for the cost of the cationic
5 polyelectrolyte. It should be noted that the amount of
polyelectrolyte used in practice of the present invention
is not selected to maximize settling or filtration rates
since in practice of the invention the bulked structure
must be capable of being formed to a clay-water system having
10 useable viscosity after addition of a suitable quantity of
deflocculating agent. In some cases, it will be necessary
during manufacture to apply mechanical work to the bulked
clay in the filter cake while adding a deflocculating agent
in order to obtain a desired low viscosity. Filter cake
15 solids vary with the equipment used and the level of vacuum
applied. Solids also vary with the particle size
characteristic of the clay. Generally, addition of
polyelectrolyte flocculant decreases the solids
content of the filter cake. The filter cake is washed with
20 water to remove soluble matter. It has been found that use
of hot water, e.g., water having a temperature above 100°F.
and below the boiling point, is beneficial. Use of a hot wash
has resulted in products having a lower Brookfield
viscosity than was obtained when wash water was at ambient
25 temperature. The use of a hot wash results in filter cakes
having a reduced content of salts. For example, filter
cakes having specific resistances ranging from about 13,000
to 50,000 ohm-cm resulted from washes at 120-140°F. while
unheated water in similar amount resulted in cakes having
30 specific resistances of about 6000 ohm-cm. It has also
been found that slurries prepared by adding dispersant to
conventionally washed (cold water) filter cakes should be
spray dried without aging the slurries for more than one or
two days because high and low shear viscosity of spray
35 dried pigments are adversely affected. When a hot wash is

- 1 used, slurries can be aged for longer times, e.g., two
weeks or longer, without detriment to the rheology of the
pigment. By using a hot wash, pigments can be shipped in
slurry form without an intermediate drying step. This
5 is of significant economic benefit.

In some cases, it is necessary to increase the
solids of the filter cake to realize the desired reduction
in Brookfield viscosity of the product, especially when the
work input during blunging is low. For example, in the
10 case of one bulked clay which produced a filter cake having a
solids content of 55%, the desired reduction in viscosity
necessitated addition of dry clay to build up to a solid
content of 59% prior to spray drying before the mechanical
work was effective.

- 15 The dewatered and washed filter cake may be
fluidized by adding a deflocculant and supplied for
shipment in slurry form as mentioned above. Alternately,
the filter cake can be fluidized by addition of a
deflocculant and then spray dried to produce a dry
20 so-called "predispersed" product in dustless form.
Although aqueous suspensions of our bulked clay can contain
added deflocculant to increase fluidity, these suspensions
are not truly in deflocculated or dispersed condition
because the bulked, flocced structure is retained. Thus,
25 these slurries can be termed "partially deflocculated"
slurries or suspensions.

The amount of deflocculating (dispersing) agent
used to fluidize the washed filter cake is typically less
than conventionally used for secondary dispersion. Thus,
30 secondary dispersant is generally used with coating grades
of clay in amount in the range of about 0.3% to 0.5% based
on the dry clay weight. Dispersant levels much greater
than 0.2% have been found to convert low viscosity slips of
clays bulked by this invention to slips having high
35 viscosity. After addition of dispersing agent, the filter

1 cake cake is then subjected to controlled agitation to
redisperse the clay particles.

The resultant bulked polyelectrolyte treated clay
product, after addition of a clay deflocculating agent, is
5 used to form high solids (at least 60% clay solids)
suspensions in water. These suspensions are then formed
into aqueous coating colors suitable for applying on paper.
Alternatively, the bulked product may be used as a filler
for paper webs.

10 The kaolin clay pigments bulked in accordance
with the present invention are especially
useful in preparing coating colors for coating lightweight
publication papers, particularly magazine stock, to achieve
coated papers having excellent opacity and printability.

15 Coat weights of light weight coated publication papers are
usually in the range of 3 to 7 lbs/3000 ft². The
printability and opacity are generally at least equal (and
usually superior) to that achieved by the commercially used
blend of delaminated kaolin clay and calcined kaolin clay.

20 Typical pigments of the invention have the
following properties:

G. E. Brightness, %	At least 85
+325 mesh residue, wt%	Less than 0.001
Particle size	
25 % Finer than 2 micrometers	At least 80%,
Average size, micrometer	0.6 - 0.8
Scattering coefficient, m ² /g	
at 457 nm	At least 0.15
at 577 nm	At least 0.11
30 Brookfield Viscosity of 62% solids slurry, cp	
at 20 rpm	Below 1000 cp, preferably below 500 cp, most preferably below 300 cp.
at 100 rpm	No greater than at 20 rpm

35

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- 1 Hercules end point, "A" bob Above 500 rpm, preferably
viscosity (rpm//dyne-cm above 800 rpm and, most
X 10⁵) preferably, no more than
16 X 10⁵ dynes at 1100 rpm.

5 We believe bulked clay pigments of the invention
possess adequate shear stability to survive production and
handling conditions such as described above, using
conventional commercial processing equipment and also are
sufficiently stable for use in high speed coaters used by the
10 paper industry.

 In preparing coating colors, conventional
adhesives or mixtures of adhesives are used with the
deflocculated clay slip. For example, useful coating color
compositions are obtained by thoroughly mixing with the
15 clay slip from about 5 to about 20 parts by weight adhesive
per 100 parts by weight of polyelectrolyte treated clay.
Such a coating color, when used for coating lightweight
publication paper, produces a product which has excellent
opacity, gloss and printability.

20 The term "adhesive" as used herein refers to
those materials known for use in connection with paper
pigments, which aid in binding the pigment particles
together and, in turn, binding the coating to the paper
surface. Such materials include, for example, casein,
25 soybean proteins, starches (dextrins, oxidized starches,
enzyme-converted starches, hydroxylated starches), animal
glue, polyvinyl alcohol, rubber latices, styrene-butadiene
copolymer latex and synthetic polymeric resin emulsions
such as derived from acrylic and vinyl acetates. When the
30 adhesive comprises a starch which is jet cooked in the
presence of added bulking pigment, it may be desirable to
heat the slurry of clay into which the polyelectrolyte is
added during preparation of the bulking pigment in order to
avoid the development of extremely viscous, unworkable
35 coating colors. Temperatures in the range of about 150° -

1 200°F. are recommended. A temperature of about 180°F. has been used with success. However, use of heat during preparation may decrease the scattering ability of the pigment.

5 The coating color compositions prepared in accordance with the present invention can be applied to paper sheets in a conventional manner.

All particle sizes used in the specification and claims are determined with the SEDIGRAPH^R 5000 particle
10 size analyzer and are reported as equivalent spherical diameters (e.s.d.) on a weight percentage basis.

In the examples, test results were obtained by the following TAPPI (Technical Association of the Pulp and Paper Industry) procedures for paper:

15 75° gloss - TAPPI Standard T480 ts-65. Value denotes the evenness or smoothness with which a coating lays on the surface of paper.

B & L opacity - TAPPI Standard T425-M-60

G. E. brightness - TAPPI Standard T452-M-58

20 Furthermore, light scattering and gloss of pigments were determined in some instances. This was done by coating the kaolin clay suspensions onto black glass plates at a coat weight of 7.0-14.0 g/m² (expressed as dry clay). The reflectance of the coatings after drying in
25 air at wavelengths 457 nm and 577 nm is measured by means of an Elrepho reflectometer. The reflectance values are converted by the use of Kubelka-Munk equations to light scattering values (m²/g). The light scattering values are a measure of the opacity potential of the clay because
30 the higher values indicate that light rather than passing through is reflected and scattered back. The higher the light scattering value, the higher the opacity potential of the clay. Reflectance is measured at two different wavelengths. The 457 nm wavelength corresponds to the

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- 1 wavelength used in the TAPPI brightness measurement and the
577 nm wavelength to that used to measure opacity.

In preparing slurries for measurement of high shear (Hercules) and low shear (Brookfield) viscosity, Engelhard Corporation procedure PL-1 was used. Brookfield viscosity was measured using TAPPI procedure T648 om-81 at 20 rpm using the #1 or #2 spindle; in some cases Brookfield viscosity was measured at 100 rpm using the #3 spindle. All slurries were formulated with optimum amount of dispersant, following the PL-3 procedure of Engelhard Corporation. Following are descriptions of PL-1 and PL-3 procedures.

PL-1 is the standard laboratory makedown method for hydrous clays at 70% solids under high shear conditions. Hydrous clays may also be makedown at other solids such as 68% solids for delaminated clays utilizing this procedure and adjusting the amount of water needed.

Equipment and Material

Analytical balance
20 Aluminum tins for weighing
Electric, forced air oven
Laboratory balance, accuracy ± 0.1 grams
Waring Blendor^R mixer (belt driven by 3/4 HP motor, with pulley to provide 10,500 RPM).
25 1000 ml and 600 ml unbreakable beakers
500 grams oven dry clay
214 grams deionized water
Dispersant (as required), i.e., tetra sodium pyrophosphate (TSPP) or organic such as Colloids 211

30 Procedure for Preparation of 70% Solids Clay Slurry

A. Formulation for 70% solids clay slurry

Deionized Water	214.0 gms
Mineral (O. D.)	<u>500.0 gms</u>
Total.....	714.0 gms

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1 B. Determine the moisture content of the mineral
to be used by drying a 3 gram sample in the oven for 30
minutes at 220°F. and cooling in a dessicator for 15
minutes before reweighing.

5 C. Place 214 grams of distilled water in the
Waring Blendor (subtract moisture in clay from 214 grams).
If a dispersant is to be used, add it to the water and mix
in the blender for 30 seconds.

 D. Weigh the oven dry equivalent of 500 grams of
10 clay into a tared beaker. Add the 500 grams of clay to the
water using a small scoop. After the addition of each
scoop of clay to the water, "jog" the switch on the motor
"off" and "on" momentarily to disperse the clay into the
water. Do not allow the motor to attain full speed during
15 the incorporation of the clay into the water. Only allow
the blender to come to full speed after all the dry clay
has been added. Excessive additional shear on the
clay/water slip (particularly in the case of delaminated
clays) will effect the reproducibility of rheological
20 measurements on a given sample.

 E. When all the clay has been added to the
water, scrape the clay on the sides of the blender into the
slurry with a spatula. Let the slip mix under full
agitation for 60 seconds.

25 F. Transfer the slip to a tared 600 ml
unbreakable beaker and cap tightly to prevent evaporation
of water. (Aluminum foil provides a good "capping"
material).

 G. Cool the clay slip to 80°F. and determine the
30 final solids content. The solids should be within $\pm 0.2\%$
or adjustment is necessary. Adjustment can be made if the
percent solids is too high by the addition of water.
However, if the percent solids is too low, the slip will
have to be discarded and a new one made.

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1 H. Rheological properties of the slip should be measured and recorded in accordance with standard methods.

Procedure for Determining Maximum Slurry Solids

Maximum slurry solids is dependent on optimum
5 dispersion. Therefore, the attainment of maximum solids requires prior knowledge of the optimum dispersant demand for the particular pigment under investigation. Follow PL-3, described hereinafter, for determining the optimum dispersant level before proceeding with the following
10 steps.

A. Follow the procedure outlined in steps C through G for the preparation of a 70% solids slurry, employing the previously determined optimum dispersant level (with some clays it may be necessary to start at
15 slightly lower solids levels to produce a flowable mixture at optimum dispersant levels).

B. Add an additional quantity of clay until a non-flowable mixture is produced by the blender.

C. Add additional dry dispersant such as TSPP at
20 the rate of 0.30% on the weight of the additional clay added in step B. Mix for 5 seconds.

D. The slurry should fluidize with the addition of the dispersant. Repeat steps B and C until the slurry no longer fluidifies after the dispersant addition.

25 E. The solids content at this point is recorded as maximum operable solids for this clay.

This method determines the amount of dispersant to obtain minimum viscosity of clay.

Optimum dispersion is determined by the PL-3
30 procedure which involves making small additions of dispersant to a slurry, mixing and then determining the Hercules and Brookfield viscosity. The dispersant level before the viscosity increases (becomes poorer) is the optimum dispersant level. The optimum dispersant level for
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- 1 Hercules viscosity may be different than the optimum Brookfield viscosity and therefore Hercules or Brookfield optimum should be specified.

Equipment

- 5 Modified Waring Blender (belt drives by 3/4 HP motor, with pulley to provide 10,500 RPM)
- Hercules Viscometer
- Brookfield Viscometer
- Talboy variable speed mixer
- 10 Constant temperature bath
- Laboratory balance (0-10 grams)
- Deionized water.
- Pigment (500 oven dried grams or 250 grams for calcined clay)
- 15 Dispersant (inorganic or organic)
- Electric, forced air oven at $105 \pm 3^{\circ}\text{C}$.

Procedure

- Prepare hydrous kaolin by PL-1 method (supra).
- Add no dispersant for predispersed clay and minimum amount
- 20 (about 0.2%) of dispersant for pulverized clay.
- B. Determine the percent solids of the sample by drying part of the sample in an oven. Solids should be $70 \pm 0.2\%$ for hydrous clay, $68 \pm 0.2\%$ for delaminated clay, $50 \pm 0.2\%$ for calcined clay and other solids as required.
- 25 C. Determine the Brookfield viscosity and Hercules viscosity of the sample.
- D. While mixing the sample using the Talboy mixer, add .05% dispersant based on pigment weight and continue mixing for five minutes.
- 30 E. Determine the Brookfield viscosity and Hercules viscosity.
- F. Repeat D and E until the viscosity increases (becomes poorer).
- G. Optimum viscosity is the amount of dispersant
- 35 added before the viscosity increases or there is no

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1 viscosity change. The solids, dispersant level and Brookfield and Hercules viscosity are reported at optimum viscosity.

5 Hercules viscosity values reported herein were measured with Hercules Hi-Lo Shear Viscometers, Model ET-24-6. These instruments are equipped with a cup to contain the sample fluid and are supplied with a series of rotating bobs and spring sets which provide a variety of shear rate conditions. One Hercules viscometer was
10 equipped with the "A" bob and was employed to operate with the 100,000 dyne cm/cm spring up to 1100 rpm for clay water slurries; the other was set to operate with a 400,000 dyne cm/cm spring up to 4400 rpm to measure viscosity of coating colors.

15 Following are details of the "A" and "E" bobs.

					Max.	Shear Rate
	Bob	Bob	Cup-Bob		Shear Rt.	Factor
	Bob Ht.	Radius	Clear.	SValue	4400 rpm	=Shear Rate
20	A 5.0 cm	1.95 cm	0.05 cm	0.00020	18196 sec.1	4.14
	E 5.0	1.98	0.02	0.00008	45900	10.42

TAPPI Procedure T648 om-81 gives further description of the procedures used to measure high shear viscosity. It is common to report high shear viscosity of
25 clay-water as either dyne-cm X 10^5 torque at 1100 rpm bob speed or as bob speed in rpm at which the maximum torque of 16×10^5 dyne-cm was obtained. Similarly, the coating color viscosity is reported as either dyne-cm X 10^5 torque at 4400 rpm bob speed or as bob speed in rpm at
30 which the maximum torque of 64×10^5 dyne-cm was obtained.

Viscometers were operated in the manner summarized below:

1. Set the graph and pen in place on the
35 recording drum (pen is placed on origin on graph paper).

1 2. Remove the cup and bob from the water bath at
80°F. and dry.

3. Pour 28 ± 2 cc. of the fluid to be tested
into the cup and set in place on the viscometer. Use of a
5 syringe will frequently facilitate filling the cup.

4. Attach the bob by rotating it
counter-clockwise making it only finger tight, then immerse
it in the fluid cup to its limit. The fluid should come up
to the top of the bob. If not, then more fluid must be
10 added until it covers the bob.

5. Start the viscometer motor (lower left front
of viscometer).

6. Press the "AUTO" switch on the control panel.
The pen will proceed to draw a graph of shear rate versus
15 shear force (torque). If the viscometer reaches its
maximum rpm setpoint, the pen will automatically return to
its starting point. However, if the pen goes beyond the
maximum allowable torque before reaching maximum rpm, the
viscometer will automatically shutdown and the recording
20 drum will have to be returned to its original position
using the crank handle.

The precision is based on a dyne-cm $\times 10^5$
reading at 1100 rpm and rpm reading at 16 dyne-cm $\times 10^5$
because these are the values reported for products. The
25 95% confidence level for the precision for three operations
at two different viscosities follows:

Average Precision

4.4 dyne-cm $\times 10^5$ at 1100 rpm	16.8%
500 rpm at 16 dyne-cm $\times 10^5$	21.4%

30 In measuring printing properties by the so-called
75° Gloss Ink Holdout Test, the procedure used was one
described in a publication by Otto P. Berberich, TESTING
PRINTABILITY OF PAPER AND BOARD WITH INK - III, November
1957 IPI. The procedure gives results relative to the

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1 printing qualities on a letter press proofpress using
halftone printing plates.

The K & N Ink Holdout Test entails applying an
excess of heavy bodied black pigmented printing ink to
5 coated paper, removing the excess and ascertaining the
contrast between the image and the background.

In measuring printability of the paper coated
with the coating color, the Helio test was used. This test
is widely used to evaluate printability by the gravure
10 method. In the test, the coated sheet is printed with a
gravure cylinder, which has a pattern of ink holding
cavities that decrease in diameter from one end to the
other. Thus the test print has large dots at one end and
small ones at the other. Skipped dots are counted starting
15 at the large-dot end, and the print quality is reported as
the distance in millimeters from the start of the test
print to the 20th missing dot. For a given coat weight,
the longer the distance in millimeters the better the
printability of the coated paper.

20 The examples describe results for making down
slurries of experimental and control pigments using
laboratory and pilot plant procedures. In the laboratory
procedure, Waring Blendor^R mixer Model 31 BL 46 was used
with a 40 oz. blender jar and cover and a Variac power
25 supply control. An amount of dispersant (typically 0.25%
Colloid 211 or 0.25% TSPP based on the dry weight of the
pigment) is dissolved in water calculated to provide a 62.0
- 62.5% solids slurry containing 300 g. of pigment. Three
hundred (300) g of pigment was added gradually at moderate
30 speed. When all of the pigment was added, the blender was
run for one minute at 50 volt Variac setting. Pilot plant
makedown was performed with a Cowles mixer (10" vessel dia,
4" blade dia, 3300 rpm blade speed, 3455 ft/min tip speed).
Dispersant was added to water, followed by addition of
35 pigment to water, as in the laboratory procedure, and mixed

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1 at slow speed. The mixer was then run at 3300 rpm for 5 minutes.

EXAMPLE I

5 The kaolin pigments used in this example were prepared from a sample of a deflocculated aqueous suspension of Georgia kaolin clay. The deflocculating agent was sodium silicate. Solids content was about 35%. The particle size distribution of the clay in the deflocculated aqueous suspensions was 55-60% less than 2.0
10 micrometers, 1.3-1.6 micrometers median diameter and 10-11% less than 0.3 micrometers diameter. This suspension was diluted with water to between 15 and 20% solids. The diluted suspension was separated by gravity sedimentation to provide supernates containing particles of 0.70 micrometers
15 ("Coarse"), 0.62 micrometers ("medium") and 0.55 micrometers ("fine") median particle size (e.s.d.). The pH of separated suspension fractions was 8-10. It was reduced to 7.0 with 10% aqueous sulfuric acid. A commercially available dimethyl diallyl quaternary ammonium chloride
20 polymer (Polymer 261 LV) concentrate was diluted to 1% solids and added to the separated suspension fractions with stirring for 5-10 minutes, and the pH of the fractions was adjusted to 2.5 with sulphuric acid. The "fine" fraction was treated with 0.07% and 0.09% polymer and the "coarse"
25 fraction with 0.07% polymer. The percentages are given on the basis of dry polymer to dry clay. The treated suspension was bleached with sodium hydrosulphite by its addition to the fractions at the rate of 10 lbs. per dry ton of clay. After standing 30 minutes, the bleached
30 fractions were vacuum filtered, and the filter cakes were washed with cold water until the filtrate measured 5000 ohm-cm specific resistance.

The washed filter cakes were then deflocculated with tetrasodium pyrophosphate by kneading the dry salt
35 into the filter cake with a spatula. The amount of

1 phosphate used was 0.1% based on the weight of dry clay.
Kneading was continued until the wet filter cake became
pourable at which point it was transferred to a Waring
Blendor^R mixer. The filter cake was then formed into a
5 fluidized suspension by agitation in the Waring Blendor
mixer. The resultant clay suspensions had solid contents
of 55 to 62%.

The fluidized clay suspensions were spray dried
and the spray dried clays were formed into coating colors
10 (56% solids) by mixing 100 parts of the treated clay with 7
parts of cooked hydroxyethylated starch (Penford Gum 280,
30% solids) and 4 parts styrene-butadiene latex (Dow Latex
620, 50% solids). All quantities in the preceding sentence
are expressed in terms of dry ingredients. The colors were
15 coated on the wire side of a 24 lb. lightweight paper
basestock using a coater equipped with an air pressure
loaded coating blade so that the coatings could be applied
in the range of 3 to 6 lbs./3000 ft² ream. The sheets
were conditioned at 50% relative humidity and 72°F and were
20 calendered on two different laboratory calendering units:
Unit A, 2 nips at 140°F and 250 pli; and Unit B, 3 nips at
140°F and 500 pli (pounds per linear inch).

The opacity and gloss of the calendered sheets
were determined using TAPPI (Technical Association of the
25 Pulp and Paper Industries) procedures. Opacity was
determined in accordance with TAPPI Standard T 425-M-60 and
Gloss in accordance with TAPPI Standard T 480ts-65.
Opacity and gloss are recorded in percent, the higher the
percent the better the opacity and gloss.

30 The opacity, gloss and printability measurements
are summarized in Table I below. The data in Table I are
linear regression values based on measurements at three
different coat weights, and then calculated for the 5
lb./ream coat weight.

- 30 -

1 For purposes of comparison, a control color was prepared wherein the pigmentation consisted of 90 parts LITECOTE^R clay and 10 parts ANSILEX^R clay. LITECOTE is a commercial delaminated pigment with a median equivalent
 5 spherical diameter of 0.70 micrometers. ANSILEX is a commercial calcined pigment with a median equivalent spherical diameter of 0.80 micrometers. The solids content of this coating color was 57%. Coating and testing
 10 procedure was identical to those used with other pigments in EXAMPLE I.

TABLE I

Properties of Sheet Coated with Coating Color
 Containing Polymer Treated Clay

15	Calender Unit A				Calender Unit B			
	Clay			Helio-			Helio-	
	Par-	Polymer	Sheet	Printa-	Sheet		Printa-	
	ticle	Conc.	Opacity	Gloss	Opacity	Gloss	bility	
	Size	(%)	(%)	(%)	(%)	(%)	(mm)	(mm)
20	Fine	0.07	88.3	49.1	63	87.1	49.3	87
	Fine	0.09	88.4	46.8	63	86.8	47.7	96
	Coarse	0.07	87.8	40.3	63	86.9	43.1	96
	Control	--	87.4	48.0	55	86.0	47.8	83

25 Data in TABLE I indicate that the experimental pigments surpassed the control (LITECOTE/ANSILEX) in printing quality and opacity, and generally produced sheet gloss comparable to that of the control. The data also show that the coarse clay tends to lose gloss but maintains printability.

30 The data also show that raising the Polymer 261LV level to 0.09% tended to maintain the bulking effect. However, clay slips and coating colors prepared using clays treated at this concentration level tend to exhibit an adverse increase in viscosity.

35

EXAMPLE II

Part A

For purposes of further comparison, the bulking of "fine" (0.55 micrometer) particle size kaolin clay was attempted using a variety of commercially available amines, amine salts quaternary ammonium salts and cationic polymers commercially used for the flocculation of particulate matter suspended in water. The procedure of EXAMPLE I used to prepare the bulked kaolin clay with Polymer 261LV was repeated with each of the flocculants including Polymer 261LV. Bulking was rated by estimating the increase in thickening of the clay dispersion containing 25% clay solids after the addition thereto of 0.07% of the flocculating agent, the percentage being based on the weight of the dry clay. If there was no observable thickening of the dispersion after the addition thereto of the individual flocculating agent, the bulking effect was rated "none." If a light creamy consistency was imparted, the bulking effect of the flocculant was rated "slight." If a thickening of the dispersion occurred which was observable when the dispersion was poured, the bulking effect was rated "some." The bulking effect caused by the Polymer 261LV was rated "considerable" because it nearly solidifies the slurry so that it would not pour.

The bulking ratings of the various flocculants evaluated in the comparative study are recorded in TABLE II below:

30

35

TABLE II

Commercial Product/		
Manufacturer's	Manufacturer's	Bulking
5 Designation	Description	Rating
Calgon/261LV	Polyquaternary Ammonium Chloride	Considerable
Betz/1190 Ammonium Salt	Polyquaternary	Slight
10 Nalco/8674 American Cyanamid	Polyquaternary	None
/S-5622	Cationic Polymer	Slight
/S-5623	Cationic Polymer	Slight
Allied Chemical		
15 /C-315	Cationic Polymer	Slight
/C-305P	Cationic Polymer	Slight
Betz/1180	Polyamine Salt	None
Betz/1185	Polyamine Salt	None
Betz/1175	Polyamino-Amide	None
20 Nalco/7607	Polyamine-epichloro-hydrine	Some*

*When concentration increased to 0.14 and 0.21% bulking effect did not approach Calgon 261 LV.

Results reported in TABLE II indicate that among the materials listed, polydimethyl diallyl ammonium chloride was unique in the bulking of the kaolin clay dispersion at the concentrations evaluated in these tests.

Part B

Further testing was carried out to evaluate the ability of various commercial cationic polymers materials supplied for use as flocculating or coagulating agents to flocculate kaolin clay suspensions and to produce dried opacifying pigments capable of being formed into clay-water solids of about 62% solids which have acceptable high and low shear rheology.

1 The kaolin clay used in the testing was a
fraction of a crude mined in central Georgia (Washington
County), the clay fraction having been selected to having a
desirable particle size distribution for purpose of the
5 invention using Calgon 261 LV polymer at the 0.08% addition
level. Particle size of the fraction was $90\% \pm 2\%$ by
weight finer than 2 micrometers; 50% by weight finer than
 $0.57\% \pm 0.03\%$ micrometers and no more than 20% by weight
finer than 0.3 micrometers. The clay fraction was provided
10 as a 20% solids slurry and contained a mixture of sodium
silicate and sodium carbonate as the deflocculating agent.
The pH was about 7. The cationic polyelectrolytes used in
the testing, in addition to Calgon 261 LV, were materials
supplied under the following registered trademarks:
15 NALCOLYTE 7107, NALCOLYTE 8102, NALCOLYTE 8100, NALCOLYTE
8101, and NALCLEAR 7122.

In carrying out the settling tests, portions of
the 20% solids slurry were diluted in graduated cyclinders
to about 10% solids by adding sufficient water to form 100
20 ml of diluted slurry (10 g dry clay/100 ml diluted slurry).
The contents of each cylinder were mixed by covering its
mouth and rapidly inverting the cylinder several times.

The effectiveness of the various treatments in
bulking (flocculating) the suspensions was investigated by
25 observing the settling characteristics of each suspension
over a period of time. The concentrations and the results
after 26 hours settling are summarized below for those
cationic materials which exhibited settling characteristic
when added at the given level similar to Calgon 261 LV at
30 the 0.08% addition level. At all time intervals between 1
and 26 hours, slurries treated with these agents using the
amounts shown below exhibited settling characteristics
similar to or slightly better than those measured with
Calgon 261 LV at the .08% level.

1	Polymer	Quantity by Weight*	mm of Supernatant Liquid	Clarity of Supernatant liquid
	7107	0.25%	30	Clear
	7122	1.00%	32	Clear
5	8100	1.00%	29	Clear
	8101	1.00%	29	Clear
	8102	0.50%	30	Clear
	Calgon 261	0.08%	29	Clear
	LV			

10 *Based on dry clay basis.

Based on these results, evaluations of pigments were made to determine opacification (light scatter) and ability to be dispersed in water at about 62% solids to form fluid slurries. Rheology of dispersed slurries was
15 evaluated at a lower solids concentration when a 62% solids slurry could not be formed. The sample of clay used in these tests was obtained from the same mine and processed in the same way used to produce a fractionated clay having the same particle size distribution as the clay used in the
20 settling experiments described above. The pigments were prepared by adding polyelectrolyte to a 20% solids clay slurry at pH 7, acidification to pH 3 with sulfuric acid, addition of K-Brite Brand sodium hydrosulfite bleach in amount of 8 pounds per ton of dry clay, aging for 30
25 minutes followed by filtration, and washing the filter cake with cold water. After drying in an oven and pulverizing, each pigment was dispersed at 62% solids with the addition of 0.025% (dry clay basis) of Colloid C-211 sodium polyacrylate dispersant by agitating in a Waring Blendor
30 mixer at a 50 volt setting for one minute. Then further polyacrylate was added, if necessary, to reach minimum Brookfield viscosity at 20 rpm. The results are summarized below:

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<u>Effect of Bulking Kaolin Clay with Various Cationic Polyelectrolytes on Optical and Rheological Properties</u>								
Slurry Properties and Composition						Black Glass Scattering m ² /g		
	% Solids	pH	Brookfield Viscosity cp. 20rpm	cp. 100 rpm	Hercules Endpoint Viscosity	457nm	577nm	
Polymer, %								
10	None	**	**	**	**	.128	.093	
	Calgon 261 LV, 0.08%	62.5	7.2	50	60	560/16	.153	.127
	Nalcolyte 7107, 0.25%	62.2	7.2	50	59	1100/1.2	.150	.102
15	Nalcolyte 8101, 1.0%	62.0	7.2	75	87	410/16	.178	.134
	Nalcolyte 8100, 1.0%	62.2	8.0	100	103	655/16	.185	.136
	Nalcolyte 8102, 0.5%	61.1	7.0	55	80	500/16	.189	.138

**Not Determined.

When similar tests were carried out with a sample of ASPR 100 hydrous kaolin, the results were in general similar; however, scatter at 457 and 577 nm was lower. The particle size of this clay was 92% by weight finer than 2 micrometers, 50% by weight finer than 0.4 micrometer, and 35% by weight finer than 0.3 micrometers.

EXAMPLE III

For purposes of still further contrast, the procedure of EXAMPLE I was repeated with the exception that the kaolin clay was not treated with Calgon Polymer 261LV prior to its incorporation in the coating color. The clay used in this test was the "fine" kaolin clay of EXAMPLE I. Polymer 261LV was added to the coating color at a

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1 concentration of 0.07% by weight based on the weight of the
untreated clay already incorporated in the coating color.
When this comparative coating color was coated on paper
base stock and calendered in Unit A, in accordance with the
5 procedure of EXAMPLE I, gloss of the calendered sheet was
lowered by 3 points. Opacity was lowered by 0.6 points
relative to sheets of equal coat weight prepared from the
same clay treated with 0.07% polymer as described earlier
in EXAMPLE I, indicating that incorporation of Polymer
10 261LV in the coating color in this manner did not produce
the desired improvement.

EXAMPLE IV

The procedure of Example I was followed to
prepare filter cakes containing kaolin particles of fine,
15 medium and coarse particle size treated with 0.07% by
weight Polymer 261LV based on the weight of the clay
solids. The filter cakes were formed into suspensions by
agitation in a Waring Blendor^R mixer in the presence of
added tetrasodium pyrophosphate in sufficient quantity to
20 yield a fluid dispersion for 1 minute using either low or
high shear conditions. Low shear conditions were obtained
with a setting of 40 on the rheostat which controlled the
power input to the mixer and high shear conditions with a
rheostat setting of 100. The Brookfield and Hercules (high
25 shear) viscosities and the light scattering and gloss of
the clay suspensions prepared under high and low shear
conditions are recorded in TABLE III below. It is believed
that dispersant addition level, which was not measured, was
not optimum.

30 The procedures of EXAMPLE I were also repeated to
prepare coating colors from the suspensions of polymer
treated clays ("fine", "medium", and "coarse" fractions) by
mixing 100 parts of the clay slips with 7 parts
hydroxyethylated starch and 4 parts styrene butadiene latex
35 (under low and high shear conditions). The amounts of the

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- 1 ingredients used in the formulation of coating colors are
 given on a dry weight coating basis. The control coating
 color was prepared in the same way as in EXAMPLE I. The
 Brookfield and Hercules viscosities, light scattering and
 5 gloss of the coating colors containing the polymer treated
 clay slips are recorded in TABLE III below.

TABLE III

Rheology, Light Scattering and Gloss of
Water Suspensions of Polymer 261LV Treated Clay

Clay Par- ticle Size	Shear	Solids (%)	<u>Viscosity</u>		Gloss %	<u>Black Glass Coating-Light Scattering</u>	
			Brookfield (20 rpm) (cps)	Hercules* (rpm)		S457 m2/g	S577 m2/g
10 Fine	Low	61.8	488	165	60	0.186	0.130
20 Fine	High	61.7	88	473	62	0.178	0.127
20 Medium	Low	61.4	188	283	58	0.182	0.128
Coarse	Low	61.8	225	---	51	0.160	0.115

25 *Hercules rpm at 16 dyne cm X 10⁵ with A-Bob.

30

35

TABLE IV

Rheology, Light Scattering and Gloss of Coating Color

Clay Par- ticle Size	Shear	Solids (%)	Brookfield (20 rpm) (cps)	Hercules Viscosity **dyne cm X 10 ⁵	Gloss %	Black Glass Coating-Light Scattering	
						S457 m2/g	S577 m2/g
Fine	Low	57.6	8450	56	34	0.182	0.142
Fine	High	57.7	8200	54	36	0.182	0.143
Medium	Low	57.2	5200	48	24	0.172	0.136
Coarse	Low	57.7	6850	--	19	0.139	0.110
Control*	--	57.9	2475	44	--	0.130	0.100

*LITECOTE/ANSILEX

** at 4400 rpm. with E-Bob.

The data recorded in TABLES III and IV indicate that regardless of particle size, the bulked clays of the invention have usable Brookfield and Hercules color viscosities; Brookfield viscosities are lower at high shear

than at low shear indicating that shearing reduced the viscosity of the slips of the dialkyl diallyl quaternary ammonium salt polymer treated clay.

The light scattering and gloss values recorded in Tables III and IV indicate that the bulking structure was not destroyed by high shear and that the properties of the Polymer 261 LV treated clay particles when dispersed under high shear conditions were only minimally altered when compared to those values of the Polymer 261 LV treated clay dispersed under low shear conditions as evidenced by the almost total lack of change in the light scattering and gloss values at S457 and S577.

EXAMPLE V

Coating colors were prepared using clay slips of 0.55 micrometer and 0.62 micrometer size kaolin clay

1 treated with 0.07% Polymer 261 LV under high and low shear
dispersion conditions following the procedure of EXAMPLE
IV. The colors were coated on paperbase stock to a coat
weight of 5 lbs/3300 ft³ ream. The coated sheets were
5 calendered in steps at 140°F and 500 pli. The steps are
designated as "nips", (1,2,3 nips). The opacity of the
calendered sheets as well as an uncalendered sheet was
determined in accordance with TAPPI T 425-M-60 and the
gloss of the sheets was determined in accordance with
10 TAPPI T480ts-65. The LITECOTE/ANSILEX control was also
prepared and tested as in the previous example.

The opacity and gloss results are recorded in
TABLE V below. The data in Table V, like that of TABLE I,
supra, are linear regression values at 5 lb/ream coat
15 weight calculated from measurements at three different coat
weights.

TABLE V

Effect of Shear Conditions on Properties
of Sheet Coated With Coating Colors Prepared
20 from Polymer 261 LV Treated Kaolin Clay

	Shear	Solids	Uncalendered	Color		Calender Unit B			
				1 Nip	2 Nip	3 Nip			
Clay Cond.		%	Op(1) Gl.(2)	Op. Gl.	Op. Gl.	Op. Gl.			
25 Fine Low	57.6	91.3	10.0	89.3	31.0	86.7	41.6	86.2	47.7
Fine High	57.7	91.2	10.3	88.0	31.8	86.8	41.7	85.7	49.1
Medium Low	57.2	91.1	7.3	88.1	26.8	86.2	37.4	85.6	44.2
Control (3)	57.9	90.2	9.9	87.7	29.2	85.2	39.3	84.7	45.5

(1) Op. = Opacity

30 (2) Gl. = Gloss

(3) Control, LITECOTE/ANSILEX 90/10 blend.

The data in Table V indicate that shear
conditions do not affect significantly the properties of
coating colors prepared by using Polymer 261 LV treated
35 clay and that the improved properties of opacity and gloss

1 exhibited by the polymer treated clay are maintained under
supercalendering conditions regardless of dispersion shear.
It should be noted that opacity and gloss of
supercalendered sheets normally decrease as the base clay
5 is made coarser.

EXAMPLE VI

The procedure of EXAMPLE I was followed to
prepare a filter cake containing kaolin clay particles of
fine (0.55 micrometer) particle size treated with 0.07% by
10 weight Polymer 261 LV (based on the weight of the clay
solids). The filter cake was formed into a suspension (55%
solids) by agitation in a Waring Blendor mixer for 1 minute
using high shear conditions. The Polymer 261 LV treated
clay suspension was added to a groundwood pulp furnish,
15 which had been previously pulped to a Canadian Standard
Freeness of 125 milliliters and a fiber consistency of
about 2.7 percent by weight, to produce handsheets
containing a variety of net mineral contents (NMC) ranging
from 4.57 to 14.28%. The pulp/clay blends were mixed in a
20 laboratory disintegrator until homogeneous suspensions,
diluted to 0.25% fiber consistency, were obtained.
Handsheets were formed from the pulp/clay suspensions using
a M/K Systems, Inc. Miniformer at a target basis weight of
35 lbs/3300 square feet (52.1 grams per square meter). To
25 insure adequate clay retention, a cationic polyacrylamide
retention aid sold under the trademark designation ACCURAC
620 was added to the stock in the Miniformer headbox at a
concentration of 0.5 pounds per ton of fiber.

The handsheets were pressed and dried on the
30 Miniformer and were conditioned at least 24 hours at 73°F,
50% relative humidity. Thereafter the brightness and
opacity were measured.

Handsheets which had been conditioned an
additional 24 hours at 73°F, 50% relative humidity were
35 calendered (B) through two nips at 500 pli.

For purposes of control, the procedures were repeated using no filler (Control A). For further purposes of control, the procedures were repeated using an untreated kaolin clay (HTTM clay), which has a median particle size of about 0.7 micrometers and is about 80% by weight finer than 2 micrometers (Control B).

The brightness and opacity results, adjusted to a basis weight of 52.1 g/m², are summarized in TABLE VI below.

TABLE VI

Properties of Sheets Filled with
Polymer 261 LV Treated Kaolin Clay

	Bulked	<u>Uncalendered</u>		<u>Calendered</u>		
	<u>Pigment</u>	<u>NMC</u>	<u>Brightness%</u>	<u>Opacity%</u>	<u>Brightness%</u>	<u>Opacity%</u>
15		4.57	67.1	86.1	67.1	86.4
		8.21	67.7	87.4	67.4	87.6
		11.42	68.3	88.3	67.8	88.5
		14.28	68.4	89.3	67.8	88.8
	<u>No filler (Control A)</u>					
20		0.00	65.5	83.0	66.4	85.5
	<u>Untreated HT Clay</u>					
	(Control B)					
		4.09	66.2	85.1	66.2	85.7
		7.26	57.6	86.1	67.3	86.3
25		9.58	67.4	87.1	67.1	87.0
		11.49	67.0	87.6	67.0	88.1

The data in TABLE VI indicate that the use of Polymer 261 LV treated kaolin clay as a filler produced a sheet that was relatively high in brightness, had relatively high opacity and in most cases did not lose these properties when the paper was supercalendered.

EXAMPLE VII

Tests were carried out to evaluate the utility of a bulking pigment of the invention in preparing offset printed lightweight coated paper. The bulking pigment was

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1 TABLE VII summarizes the results obtained by
testing the rheology of coating colors containing the
experimental bulked pigment and the clay evaluated for
purposes of comparison.

5 TABLE VIII summarizes the results of optical and
printing properties of coated sheets.

TABLE VII
RHEOLOGY OF COATING COLORS

		50 LVHT	Experimental
10	Pigmentation	<u>50 LITECOTE</u>	<u>Pigment</u>
	Coating Color Rheology		
	Solids (%)	57.1	57.2
	pH -- 8.0		
	Brookfield Viscosity 2500	3350	8250
15	Spindle No. 4		
	20 RPM, 80°F		
	HEP "E" (dyne-cm * 10 ⁻⁵)		
	400,000 dyne springs 19	22	33
	E-bob, 4400 RPM max.		
20	*Hercules "End Point"		

25

30

35

1

TABLE VIII

OPTICAL AND PRINTING PROPERTIES OF COATED SHEETS

Pigmentation		50 LVHT	Experimental
	LVHT	50 LITECOTE	Pigment
5	Coat Weight #/3000 sq.ft.	4.0	4.5
			4.0
Calendered Optical Properties			
	75 Deg. Sheet Gloss (%)	47.4	49.1
			46.5
	Elrepho Brightness (%)	69.4	69.9
			69.6
	Opacity (%)	84.1	84.5
			85.1
10	Calendered Paper Properties		
	Sheffield Smoothness	16	11
			23
	Sheffield Porosity 3 disc	49	44
			206
Printing Properties			
	K&N Ink Receptivity Change	19.6	19.4
			28.8
15	IGT Dry Pick vvp w/ #24 oil	19	18
			17
Vandercook Flat Prints			
	75 Deg. Print Gloss (%)	77.8	78.5
			68.9
	Optical Density	1.60	1.60
			1.55
	Print-through	76.1	76.6
			76.1
20	Ink Transfer (mg)	36.9	32.6
			40.2
RI Printability			
	Wet Pick (1)	3	3
			10

(1) Lower numbers indicate better wet pick.

Viscosity data reported in TABLE VII demonstrate the higher viscosity of the experimental pigment color.

The data in TABLE VIII demonstrate the bulking effect of the experimental pigment which was evident by its good performance in opacity, porosity, K&N ink receptivity and print-through.

30

EXAMPLE VIII

The following test indicates how viscosity increases can be used to determine when an effective amount of polymer is added. The results of the test also confirm the belief that Calgon 261 LV polymer functions to flocculate high solids dispersions of hydrous kaolin clay.

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1 The clay used in the tests was ULTRAGLOSS 90½ clay, a
 predispersed, ultrafine particle size kaolin clay, 98% by
 weight of the particles being finer than 2 micrometers 90%
 by weight being finer than 1 micrometer and median particle
 5 size of about 0.3 micrometers. The clay was provided as a
 spray dried product containing about 0.35% by weight of
 tetrasodium pyrophosphate which was added to a slip of the
 clay prior to spray drying. Calgon 261 LV was added in
 increments to a 65% solids deflocculated suspension of the
 10 clay (700 g clay.) This solids concentration was used to
 facilitate the observation of the thickening effect of the
 polymer addition. Brookfield viscosity (20 r.p.m.) was
 measured after each addition until the desired total of
 0.07% dry weight of polymer was added based on the dry
 15 weight of the clay. Initial additions appeared to slightly
 decrease in viscosity. However, when about 60% of the
 amount generally effective to produce a bulked clay product
 using fine clay was added, viscosity began to increase and
 continued to increase until the total polymer addition was
 20 0.07% (dry weight) based on the dry weight of the clay. The
 data is in TABLE IX.

TABLE IX

Effect of Addition of Calgon 261 LV Polymer
 on Viscosity of High Solids Deflocculated
 25 Clay Suspension

25	Clay Suspension	
	Volume of Total Added (1% Solution of Polymer 261 LV)	Brookfield Viscosity, cp
	0 ml	180
	10 ml	164
30	20 ml	152
	30 ml	186
	40 ml	272
	50 ml*	400

*Final solids = 59%

35

1

EXAMPLE IX

The following is another example of the invention carried out using production scale equipment.

A high purity kaolin crude clay from a deposit in
 5 Washington County, Georgia, known as North Jenkins crude, was degritt, dispersed in water with sodium silicate having a $\text{Na}_2\text{O}/\text{SiO}_2$ weight ratio of about 3/1 and sodium carbonate. The suspension was then fractioned in a centrifuge to 87% finer than 2 micrometers. The median
 10 particle size of the fractionated suspensions was 0.59 ± 0.03 micrometers; weight percentage finer than 0.3 micrometers was 17%. Solids were about 20% and pH about 7. The suspension was then passed through a high intensity magnetic separator magnet for purification. Calgon 261 LV
 15 polymer was added to the suspension of purified clay at the 0.08% level based on dry weight of clay. The polyelectrolyte was added as an aqueous solution of about 2% (wt.) concentration. The pH was adjusted to about 4 to 4.5 by addition of sulfuric acid and the sodium
 20 hydrosulfite ($\text{Na}_2\text{S}_2\text{O}_4$) bleach was added in amount of 6#/ton of clay. The slurry was then filtered on a rotary vacuum filter to produce a filter cake having 55-60% solids. The filter cake was thoroughly washed with cold water and dispersed by adding tetrasodium pryophosphate in
 25 amount of 0.1% based on the dry clay, followed by kneading. The pH of the fluidized cake was adjusted to 6.5 - 7.0 by addition of sodium hydroxide. The suspension was then dried by spray drying.

Using this crude, desired properties were:

30	G. E. Brightness, %	86.5 - 87.0
	+325 mesh residue, %	0.001
	Scattering coefficient(s), m^2/g	
	at 457 nm	0.160
	at 577 nm	0.120 - 0.140

35

1 The scattering values shown above for the
 experimental pigment are two times greater than typical No.
 1 grades of domestic hydrous coating clay. When such an
 experimental pigment is used as the sole coating pigments
 5 in offset paper coating formulations at 3 to 6 lbs/3300
 ft² coat weights, these scattering values translate to
 sheet opacities comparable to those normally obtainable
 with paper coatings containing from 5 parts by weight of
 TiO₂ or 10 parts calcined clay. In addition, the greater
 10 hiding of the basestock can result in coated offset paper
 brightness comparable to those obtainable using coating
 clay having higher brightness. Pigments of the invention
 can have higher brightness values than those mentioned
 above provided the clay feed to which polyelectrolyte is
 15 added has a higher brightness and/or colored impurities are
 removed by flotation or other means.

The viscosity of dispersed clay-water slurries of
 pigments of the invention prepared from this and similar
 fractions of crude kaolin is typically intermediate that of
 20 standard delaminated clay and fine particle size calcined
 clay used in paper coating. This is demonstrated by the
 following summary of typical properties:

	ANSILEX	Product of	NUCLAY	HT No. 2
	<u>Calc. clay</u>	<u>the Invt.</u>	<u>Delaminated Clay</u>	<u>Coat. Clay</u>
25				
Solids %	50.0	62.3	67.8	69.9
pH	6.4	6.8	6.7	6.3
Brookfield				
Viscosity (cps)				
30 20 rpm	30	210	320	205
100 rpm	50	165	290	145
Hercules End	840/16.0	1100/9.9	340/16.0	1100/4.3
Point Viscosity				
"A" Bob, 27°C.				

1 It has been found that makedown is best at 62-63%
maximum solids for dispersing. Higher solids are possible
but difficult and can yield high Brookfield viscosities.

The rheology, scatter and gloss of the spray
5 dried pigments of the invention will vary with solids of
dispersion, amount and species of additional dispersant, if
any, and pH. Also, the amount of work input used to
prepare the pigment slurry before and after spray drying
will affect these properties. The effect of some of these
10 variables is shown by data for the pigment prepared in this
example with 0.08% Calgon 261 LV. Makedown was by the
laboratory procedure described above.

	%	Waring*	Colloid	Viscosity		m^2/g	
				20 rpm		Scattering	
15	<u>Solids</u>	<u>Speed</u>	<u>211%</u>	<u>Brookfield</u>	<u>Hercules**</u>	<u>S457</u>	<u>S577</u>
	62	50 V	0.025	100	1100/3.7	.174	.126
	62	110 V	0.025	90	1100/2.0	.162	.114
	64	50 V	0.025	140	780/16	.175	.129
	64	110 V	0.025	150	1100/6.1	.160	.112
20	66	50 V	0.025	230	450/16	.172	.125
	66	110 V	0.025	320	535/16	.164	.117
			<u>TSPP%</u>				
	62	50 V	0.020	450	1080/16	.187	.138
	64	50 V	0.020	495	520/16	.182	.132

25 *Model 31 BL46, Voltage settings on power input
controller

**A-Bob, 27% rpm/dyne-cm $\times 10^5$.

EXAMPLE X

The kaolin pigments used in this example were
30 prepared using laboratory scale equipment from a sample of
a deflocculated aqueous suspension of degrittred, previously
fractionated Georgia kaolin clay. The crude clay from
which the degrittred clay was obtained was from the Scott
mine, Washington County, Georgia. The degrittred clay had
35 the following particle size distribution: 82% less than 5

1 um; 68% less than 2 um; 52% less than 1 um; 50% less than 0.95 um (weight median size); 25% less than 0.50 um; 4% less than 0.3 um. The degrittied clay as received was at about 35% solids and contained sodium silicate as a deflocculating agent. This suspension was fractionated in conventional manner in a centrifuge to prepare three particle size fractions as follows: 79% less than 2 um; 83% less than 2 um; 90% um. The particle size distribution the 83% less than 2 um fraction was 50% less than 0.6 um and 18% less than 0.3 um. The pH of the fractions was adjusted to 4.5 with sulphuric acid and bleached with sodium hydrosulphite by its addition to the fractions at a rate corresponding to 4 pounds per ton of dry clay. Calgon Polymer 261 LV concentrate, diluted to 1% concentration, was added to each of the separated suspension fractions with moderate stirring for 5-10 minutes. Each fraction was treated with the polyelectrolyte in amount to result in addition of 0.08%, 0.12% and 0.15% polyelectrolyte. The percentages are given on the basis of dry polymer to dry clay. In all cases, the suspensions thickened more than the flocculation induced by acid and bleach addition. The treated slurry appeared to have "creamy" consistency. After standing 30 minutes, each bleached and treated fraction was vacuum filtered, and the filter cakes were washed with cold water until the filtrate measured at least 5000 ohm-cm specific resistance.

A portion of each of the nine washed filter cakes was then deflocculated with either tetrasodium pyrophosphate in amount of 0.025% based on the dry clay weight or sodium polyacrylate, Colloid 211, in amount of 0.025% based on dry weight of the clay, by working the 40% solution of the deflocculant into the filter cake with a motor driven paddle agitator. Agitation was continued until the wet filter cake became pourable. The fluidized clay suspensions were spray dried in conventional manner. The dried pigments were redispersed in water with a Waring

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1 Blendor mixer. (Model 31 BL 46). The procedure used was
to dissolve the dispersant in water, and add the pigment
gradually to the water while operating the mixer at
moderate speed. When all pigment was added, the blendor
5 was run for one minute at 50 volts Variac setting. The
resultant clay suspensions had solid contents of about 62%.

Viscosity of the spray dried clays was measured
using the Brookfield instrument at 20 rpm and the Hercules
viscometer ("A" bob). Light scattering was also tested at
10 457 nm and 577 nm by the black glass method. The results
are reported in Table X.

Data in Table X show that addition of the
quaternary ammonium polyelectrolyte at the 0.03% level
resulted in a pigment having lower opacification than when
15 used at higher levels. At the 0.15% or 0.13% addition
level, scatter was better than at lower levels but low
shear and/or high shear were higher than desired.
Generally, the best compromise between the measured optical
property (scatter) and rheology was achieved at
20 polyelectrolyte addition levels of 0.06% and 0.08%. The
data in Table X also appear to indicate that light scatter
was affected by the particle size of the clay.

EXAMPLE XI

Some experimental pigments prepared under EXAMPLE
25 X were further evaluated. Another sample (Sample 4) was
prepared from the same 90% less than 2 um fraction,
utilizing the same procedures except that 0.08% Calgon 261
LV was added before spray drying. Thus Samples 2 and 4
were prepared from the same clay using the same amount of
30 polyelectrolyte but in Sample 2 polyelectrolyte were added
before filtration and in Sample 4 polyelectrolyte was added
after filtration. The samples evaluated are identified as
follows:

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1	Sample No.	% Calgon 261 LV	% less than 2 um clay in Feed
	1	0.08%	80
	2	0.08%	90
	3	0.15%	83
5	4	0.08%	90

Experimental pigments were made down to 62.0% solids slurries and slurries having minimum Brookfield viscosity were obtained by adding a suitable amount of Colloid 211. These slurries were made down in a Waring
 10 Blendor at 40 volts for one minute. Brookfield and Hercules viscosities were measured using procedures described above.

The coating colors were prepared based on the following rotogravure formulation:

15	Pigment	100
	Penford Gum	7
	Dow Latex 620 A	4
	Nopcote C-104	0.5

Coating colors were made down to approximately
 20 57% solids. The pH of each color was adjusted to 8.0 with ammonium hydroxide. Brookfield and Hercules viscosities were measured using standard laboratory procedures. It was necessary to dilute the color containing the pigment prepared with addition of 0.15% Calgon 261 LV to 56% solids
 25 because Brookfield viscosity of a 57% solids color was too high.

The wire side of St. Regis rotogravure basestock was coated with each coating color on the Keegan blade coater at three coat weights. Dewatering, typical of
 30 pigments of this type, was observed during the application of all colors containing experimental pigment. It was most severe with the pigment with 0.15% Calgon 261 LV. The coated sheets were dried in a rotary dryer and conditioned overnight at 72°F. and 50% relative humidity. The sheets
 35 were then weighed and coat weights determined.

1 When the required coat weights were obtained, the
sheets were calendered through two nips at 140°F. and 250
pli. Calendered sheets were conditioned overnight at 72°F.
and 50% relative humidity and tested for gloss, Elrepho
5 brightness, opacity and Heliotest.

 The rheology of clay-water suspensions of each
pigment were compared. The results appear in Table XI.
The slurry of pigment to which 0.15% Calgon 261 LV was
added had poor high shear rheology, possibly due to
10 insufficient shear for this treatment level during
makedown. The coating color of this pigment also had a
high Brookfield viscosity at 57% solids. Dilution to 56%
solids still yielded a high Brookfield viscosity.

 Optical properties of calendered sheets coated
15 with experimental pigment and the control were measured.
The control consisted of a blend of 90% Litecote and 10%
Ansilex. The gloss of both samples prepared from fine feed
was equal to or greater than the control at all coated
weights. Pigments made from coarser feed gave lower gloss
20 than the control. Elrepho brightness of the experimental
pigments was equal to or greater than the control at low
coat weight. Rotogravure printability and opacity of
experimental pigments was same or better than the control
at all coat weights.

25 It was found that Sample 2 prepared from fine
feed and 0.08% polyelectrolyte gave gloss, opacity and
Heliotest values greater than the control. Elrepho
brightness of coated sheets was equal to or greater than
the control at 3.9 and 6.1 pounds per 3300 square foot but
30 less than the control at 5 pounds per 3300 square foot.
The overall performance of this pigment was superior to the
other experimental samples in the study and generally equal
to the control. Sample 4 in which polyelectrolyte was
added after filtration and before spray drying was overall
35 inferior to Sample 2.

EXAMPLE XII

1 Two samples of kaolin clay treated with 0.08%
Calgon 261 LV polymer (EXAMPLE X) were made down in water
at 62.2% and 64.2% solids at optimum conditions (dispersed
5 with 0.025% Colloid 211). These samples were placed in a
shaker water bath at 100°F. The shaking frequency was slow
at about 100 cycles per minute with the amplitude of about
7 cm. Viscosity and black glass scattering were measured
at the beginning and every week thereafter. It was found
10 that light scattering increased but high shear and low
shear viscosity also increased with prolonged storage at
elevated temperature. The slurries had a tendency to
thicken, but they could be mixed with a spatula to a
workable and measurable consistency. It was subsequently
15 found that the use of hot (120-140°F.) water to wash filter
cakes obviated the tendency of the slurries to thicken
during storage.

Attempts were made to evaluate changes in the
particle size distribution curves of clays after they were
20 bulked in accordance with this invention. These attempts
have not yielded clearcut results. Those skilled in the
art are aware of the fact that particle size distribution
curves of clays are obtained by testing deflocculated
aqueous suspensions. The rate of shear used to prepare
25 deflocculated aqueous suspensions of bulked clays of the
invention strongly influences the observed particle size
distribution of the bulked clay. Furthermore, when using
the SEDIGRAPH analyzer, deflocculated clay suspensions being
tested are diluted and subjected to vibration in a sonic
30 bath. Such treatment could conceivably change the particle
size distribution of a bulked clay by breaking down
assemblages. In general, such testing indicates that
bulk clay products of the invention are coarser than the
clay from which the bulked clay products are derived at
35 least in the fine particle size ranges. For example, there

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1 generally appears to be a 50% reduction in the weight
percentages of particles finer than 0.3 micrometers.
Starting clay, the particles of which are about 20% by
weight finer than 0.3 micrometers, usually produces bulked
5 products which when sheared at a low shear rate (Waring
Blendor mixer with a variac setting of 30-40 volts) appear
to be about 10-11% by weight finer than 0.3 micrometers.
Changes in size distribution of particles larger than 0.3
micrometer are generally less than the accuracy limit of
10 the SEDIGRAPH instrument.

While specific components of the present system
are defined above, many other variables may be introduced
which may in any way affect, enhance or otherwise improve
the system of the present invention. For example, the
15 polyelectrolyte treated clay of the present invention may
be blended with other pigments having specific and unique
properties to produce coating colors. Examples of such
pigments are high glossing kaolin clay or a delaminated
kaolin clay. These are intended to be included herein.

20 Although variations are shown in the present
application, many modifications and ramifications will
occur to those skilled in the art upon a reading of the
present disclosure. For example, polyelectrolyte can be
added to unbleached clay at an alkaline dispersion pH, at
25 acid pH levels which are typically encountered in reductive
bleaching, after the addition of the hydrosulfite and
sulfuric acid bleaching reagents to the repulped filter
cake both in the presence or absence of deflocculating
agents, etc. Furthermore, the use of diallyl homopolymers
30 has been described. Those skilled in the art will
recognize that the polymer can be modified by introducing
other monomers during the polymerization so as to modify
the diallyl ammonium polymer salt.

TABLE X
BULKING PIGMENTS PREPARED FROM SCOTT CRUDE KAOLIN

% Calgon 261 LV added to Filter Feed	Particle Size of Fractionated Clay	Dispersant 0.025% wt.	Filter Cake			
			62% Solids Brookfield Viscosity @ 20 rpm (cps)	62% Solids Hercules endpoint Viscosity "A" Bob	60% Solids Black Glass Scatter 457 nm	577 nm
0.03	83% - 2 um	TSPP C-211	57 48	2.0/1100 2.0/1100	0.153 0.148	0.106 0.102
0.06	83% - 2 um	TSPP C-211	42 35	2.8/1100 1.6/1100	0.163 0.147	0.113 0.102
0.08	83% - 2 um	C-211	55	920/16	0.182	0.130
0.15	83% - 2 um	C-211	3325	*200/16	0.187	0.148
0.06	90% - 2 um	TSPP C-211	83 100	"13.4/1100 6.9/1100	0.198 0.193	0.143 0.143
0.08	90% - 2 um	TSPP C-211	132.5 65	*16/460 16/880	0.206 0.195	0.150 0.146
0.13	90% - 2 um	TSPP C-211	77.5 135.0	16/560 *16/410	0.200 0.200	0.150 0.147
0.03	79% - 2 um	TSPP C-211	66.5 56.0	4.3/1100 4.2/1100	0.159 0.159	0.112 0.107
0.06	79% - 2 um	TSPP C-211	127 55	15/1100 9.1/1100	0.177 0.175	0.132 0.126
0.08	79% - 2 um	TSPP C-211	83.5 57.5	*16/520 16/1100	0.186 0.180	0.141 0.134
0.13	79% - 2 um	TSPP C-211	Gel * 19	(Not tested) *16/420	(Not tested) 0.181	(Not tested) 0.139

* These viscosities are higher than desired.

Table XI

CLAY-WATER DISPERSION PROPERTIES OF BULKING PIGMENTS AT 62% SOLIDS

Sample No.	1	2	3	4
Z < 2 microns	80	90	83	90
"				
Z Calgon 261 LV	0.08	0.08	0.15	0.08
Z Colloid 211	0.025	0.025	0.05	0.075
Shear *	Moderate	Moderate	Moderate	Moderate
Z Solids	62.0	62.0	62.0	62.0
Brookfield Viscosity, 20 rpm	60	60	55	400
Marcules "A"	1100/15.6	690/16	290/16	1100/4.7
1100 rpm/ dyne-cm X 10 ⁵				

* Moderate = Waring Blendor, 1 minute, 40 volt setting

C L A I M S :

1. An opacifying pigment comprising particles of hydrous kaolin clay flocculated with a minor amount of cationic polyelectrolyte flocculant, said pigment having a G. E. brightness of at least 85% and scattering values at 477 nm and 577 nm higher than those of said clay in the absence of said polyelectrolyte, and being capable of being formed into a 62% solids fluid slurry.
2. A pigment according to claim 1 wherein the Hercules endpoint viscosity of a 62% solids slurry at 16×10^5 dyne-cm is at least 500 rpm, preferably at least 800 rpm, as measured using the "A" bob and the Brookfield viscosity is below 1000 cp, preferably below 500 cp, when measured at 20 rpm.
3. A pigment according to claim 1 or 2 which also contains deflocculating agent.
4. A pigment according to any preceding claim wherein the polyelectrolyte comprises quaternary ammonium polymer salt, e.g. diallyl ammonium polymer salt in which the ammonium group may be partially or fully substituted by C_1 to C_{18} alkyl group(s), preferably dimethyl diallyl ammonium polymer salt having a molecular weight of e.g. 1×10^4 to 1×10^6 and preferably 50,000 to 250,000.
5. A pigment according to any of claims 1 to 3 wherein said polyelectrolyte comprises at least one polyelectrolyte selected from polyamines, copolymers of aliphatic secondary amines with epichlorohydrin, poly(quaternary ammonium)polyether salts, and aminomethylated polyacrylamide quaternary compounds.
6. A method for preparing a bulked pigment suitable for use in coating or filling paper which comprises preparing a fluid aqueous suspension of particles of kaolin clay, adding thereto water-soluble cationic polyelectrolyte flocculant and at least partially dewatering said suspension to recover the resulting bulked clay, the amount of said cationic polyelectrolyte (e.g. about 0.03% to about

0.15% based on the dry weight of the clay) being sufficient to substantially thicken and flocculate said fluid suspension and result in a clay pigment having improved opacification but being limited such that said bulked clay is capable of being formed into a 62% solids fluid aqueous slurry which preferably has a Brookfield viscosity below 1000 (most preferably below 500) cp when measured at 20 rpm and a Hercules endpoint viscosity at 16×10^5 dyne-cm of at least 500 (most preferably at least 800) rpm or higher as measured using the "A" bob.

7. A method according to claim 6 wherein the polyelectrolyte comprises quaternary ammonium polymer salt, e.g. diallyl ammonium polymer salt in which the ammonium group may be partially or fully substituted by C_1 to C_{18} alkyl group(s), preferably dimethyl diallyl ammonium polymer salt having a molecular weight of e.g. 1×10^4 to 1×10^6 and preferably 50,000 to 250,000.

8. A method according to claim 6 wherein the polyelectrolyte comprises at least one polyelectrolyte selected from polyamines, copolymers of aliphatic secondary amines with epichloro-hydrin, poly(quaternary ammonium)polyether salts, and aminomethylated polyacrylamide quaternary compounds.

9. A method according to any of claims 6 to 8 wherein at least one of the polyelectrolyte and the fluid aqueous suspension is hot when the polyelectrolyte is added.

10. A method according to any of claims 6 to 9 including the steps of acidifying the resulting flocculated clay suspension, bleaching the clay in said suspension (e.g. with hydrosulfite salt), filtering the acidified suspension to recover bulked clay, washing the filtered clay and adding deflocculant to the recovered bulked clay to provide a fluid suspension of bulked clay.

11. A method according to claim 10 wherein the fluid suspension of bulked clay has a clay solids content of 60% to 65% and optionally

is shipped in this form, or has a solids content of 55 to 60% and is spray dried, preferably without aging, to provide a pigment capable of being dispersed in water at a clay solids content of 62% or higher.

12. A method according to claim 10 or 11 wherein the filtered clay is washed with hot water.

13. A method according to any of claims 6 to 12 wherein the clay to be treated contains less than 35% by weight, preferably less than 20% by weight, of particles finer than 0.3 micrometers and from 80% to 95% by weight, preferably from 85% to 90% by weight, of particles finer than 2 micrometers.

14. A method according to any of claims 6 to 13 wherein the clay suspension to which said polyelectrolyte is added is a deflocculated suspension.

15. A method for preparing a bulked clay pigment capable of being dispersed in water to form a high solids clay-water suspension having high shear and low shear viscosity suitable for use in coating printing paper which comprises preparing a deflocculated aqueous suspension of kaolin clay particles of which no more than 20% by weight are finer than 0.3 micrometers, the weight median particle size is about 0.5 to about 0.6 micrometers and from 80% to 95% by weight are finer than 2 micrometers, adding thereto about 0.06 to about 1.0% by weight of water-soluble cationic polyelectrolyte (e.g. polydimethyl diallyl ammonium chloride), thereby thickening and flocculating said suspension, acidifying said suspension to a pH of about 2.5 - about 4.0 and adding sodium hydrosulfite to the acidified suspension to bleach said clay, filtering the suspension to recover the resulting bulked bleached clay product, washing the filter cake with hot water and adding to the washed filter cake less than 0.3% of deflocculating agent (e.g. sodium polyacrylate), based on the dry clay weight to form a fluid

deflocculated slurry, the amounts of said polyelectrolyte and said deflocculating agent being such that said pigment can be formed into a 62% aqueous slurry having a Hercules endpoint viscosity of 800 rpm or higher at 16×10^5 dyne-cm as measured using the "A" bob and a Brookfield viscosity below 500 cp as measured at 20 rpm, the fluid deflocculated slurry optionally being spray dried to recover dry pigment.

16. A coating color composition suitable for coating paper webs comprising a deflocculated suspension in water of kaolin clay and adhesive (e.g. a mixture of styrene-butadiene polymer and starch) for the clay, the clay having been treated with a small but effective amount of water soluble cationic polyelectrolyte flocculant (e.g. diallyl ammonium polymer salt wherein the ammonium group is either partially substituted with an alkyl group having 1 to 18 carbon atoms or totally substituted with alkyl groups having 1 to 18 carbon atoms, preferably polydimethyldiallyl ammonium chloride having a molecular weight 50,000 to 250,000) to prepare a bulked product, and then deflocculated to form a fluid slurry of 60% clay solids or higher.

17. A composition according to claim 16 wherein the clay is treated with about 0.03 to about 0.15% (preferably less than 0.1%) of the polyelectrolyte based on the dry weight of the clay and the clay being treated contains less than 25% by weight (preferably less than 20% by weight) of particles finer than 0.3 micrometers and from 80% to 95% (e.g. 85 to 90%) by weight of particles finer than 2 micrometers and preferably has a weight median particle size of about 0.5 to 0.6 micrometers.

18. A coating color containing pigment according to any of claims 1 to 5 or obtained by a method according to any of claims 6 to 15.

19. A paper web coated with a pigment or composition according to any of claims 1 to 5 and 16 to 18, the coated paper web preferably being printed by gravure or offset.



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